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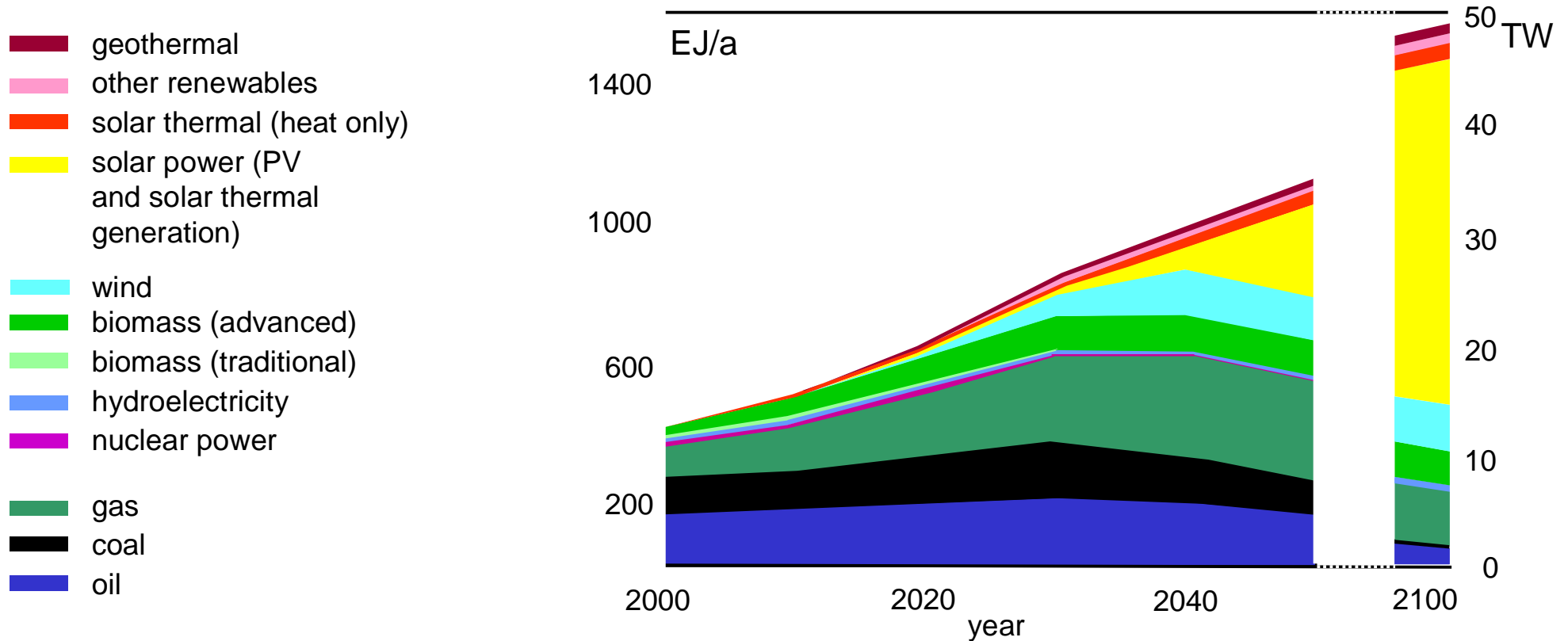
# Solar Energy Conversion – Solar Electricity Generation, Photovoltaic Energy Conversion

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# Exemplary path, global primary energy



Source: German Advisory Council on Global Change, 2003, [www.wbgu.de](http://www.wbgu.de)

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# Status of Solar Electrical Energy Conversion, 2005

- photovoltaics:  
globally installed 5 500 MW,  
annual growth rate ~30%
- optically concentrating PV power plants:  
pilot projects
- solar thermal power plants:  
globally installed 354 MW,  
market restart

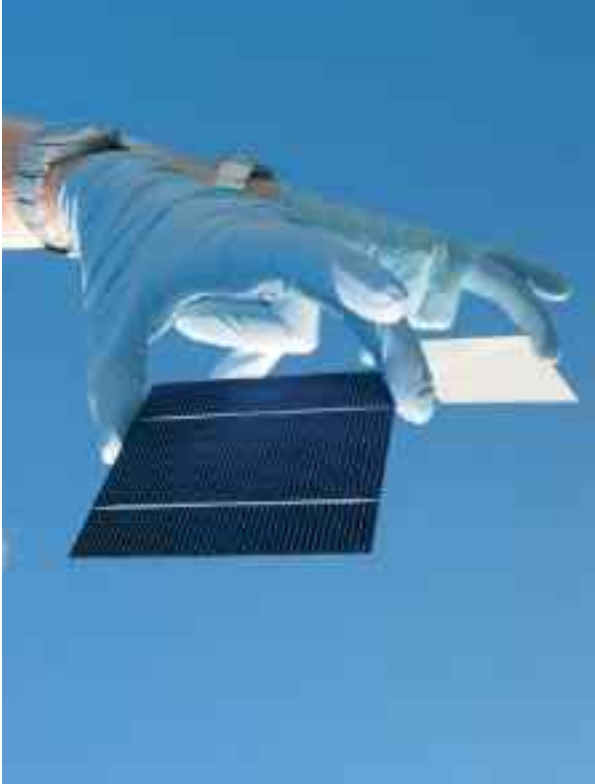
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# Solar Thermal Power Plants



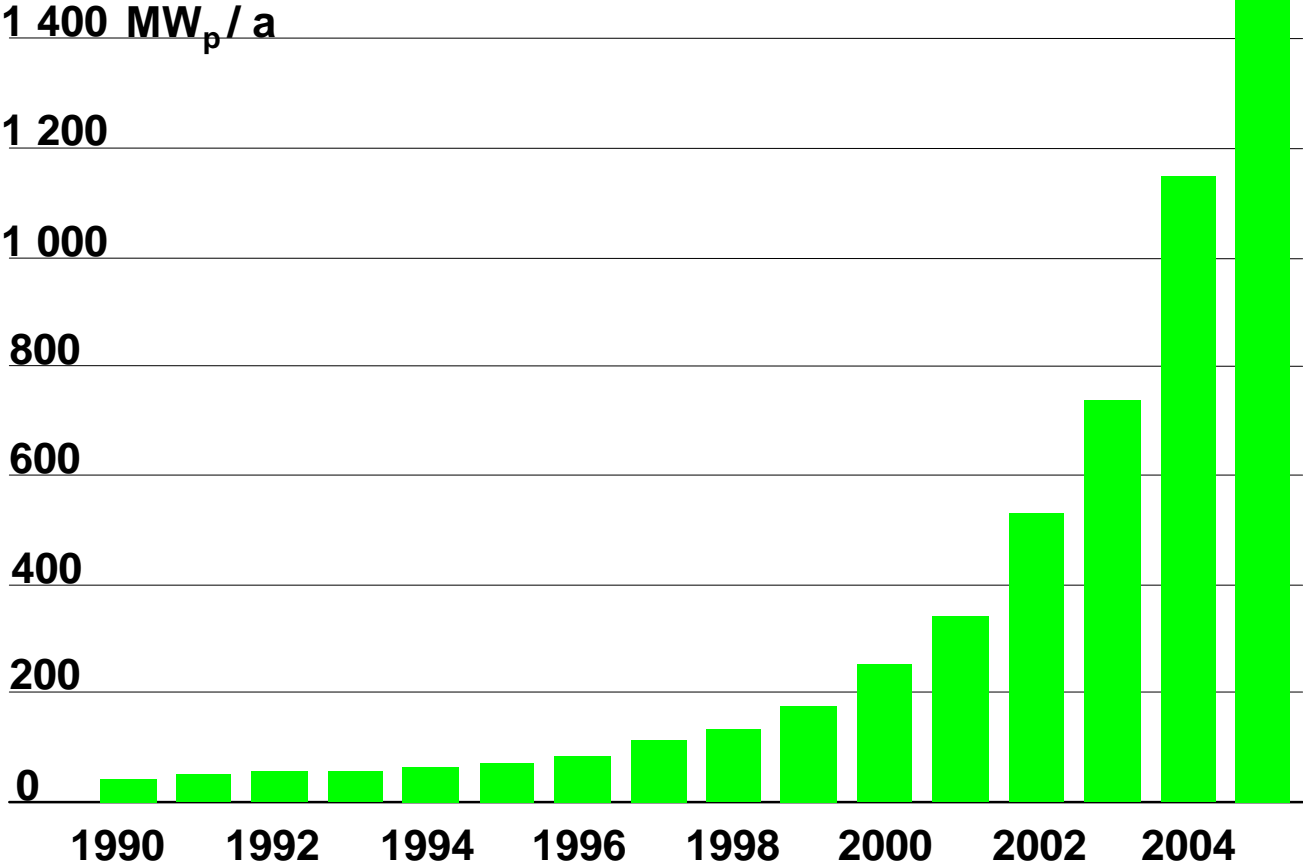
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# Photovoltaic energy conversion



Source: Fraunhofer ISE; Bundesverband Solarindustrie, [www.bsi-solar.de](http://www.bsi-solar.de)

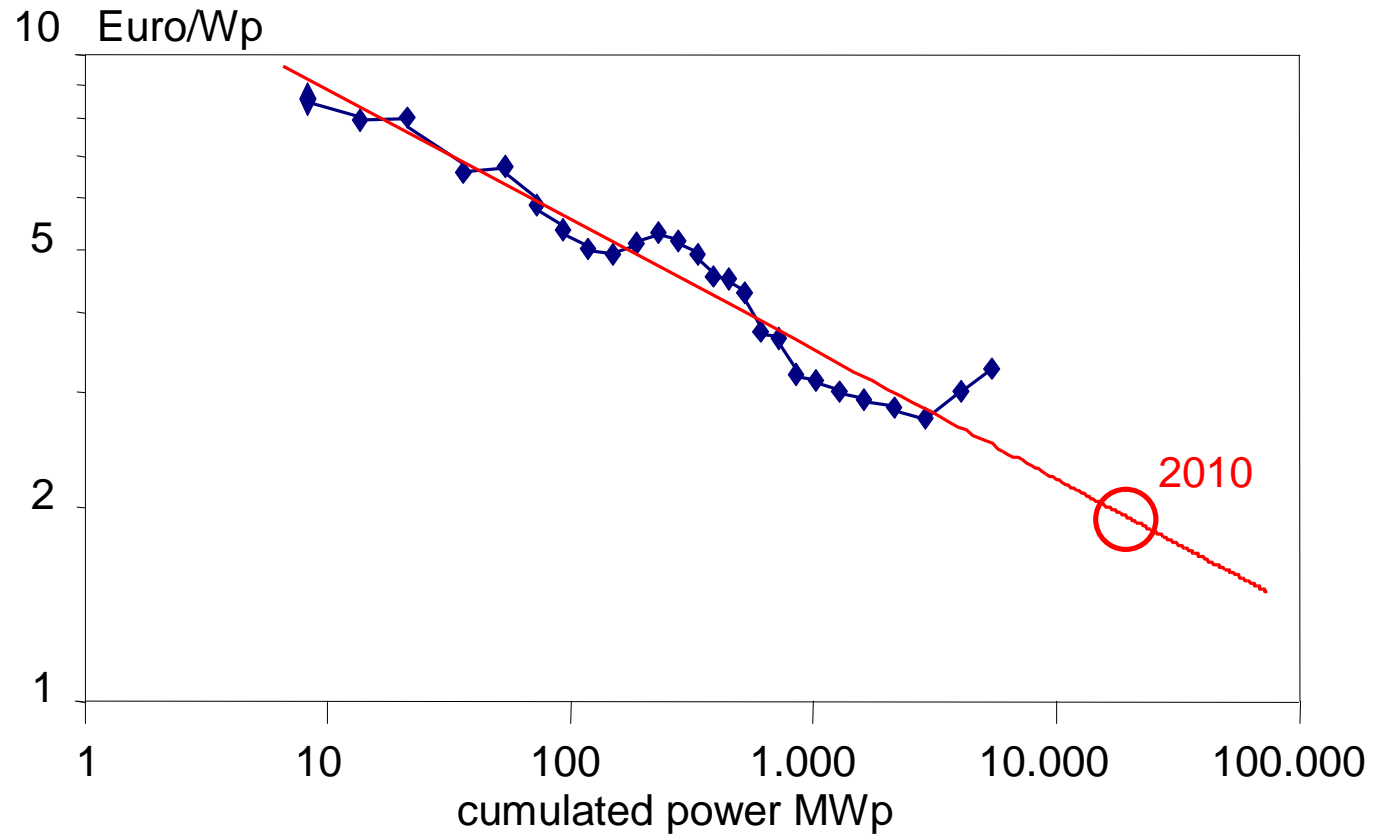
# Global photovoltaic market, modules



Source: PSE GmbH, 2005

# Si flat plate PV modules, price experience curve

1 Euro = 1,2 USD



Source: PSE GmbH, 2005

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Technological maturity of photovoltaic energy conversion has been proven

Further cost reduction in PV through

- less material consumption
- higher efficiency
- optimised manufacture

This requires intensive basic and application oriented R&D, mostly incremental

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# Today's main technology routes in PV

## **silicon wafer**

power and architecture, ...

## **thin films**

architecture and power, ...

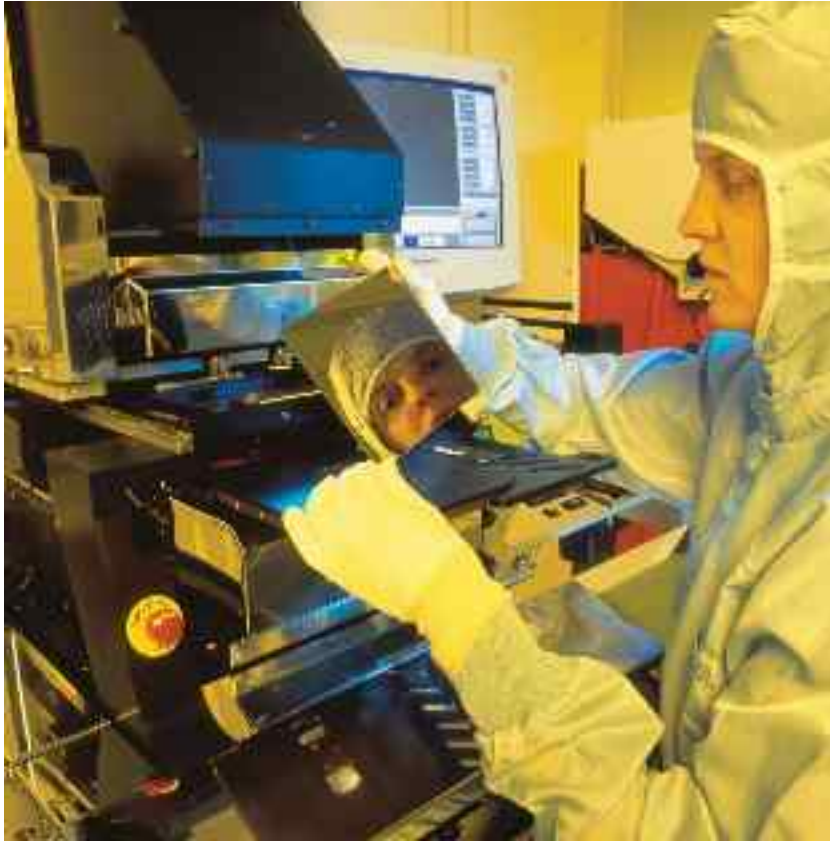
## **PV under optical concentration**

power plants

## **novel concepts**

Adapted from W. Hoffmann

# From basic research to manufacturing technologies



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# High-efficient ultra-thin solar cell

Efficiency 20,2%

Wafer thickness 42  $\mu\text{m}$



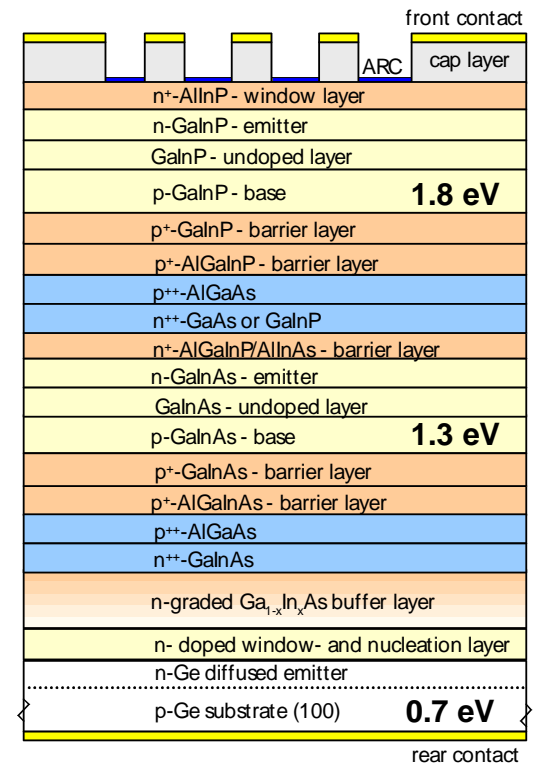
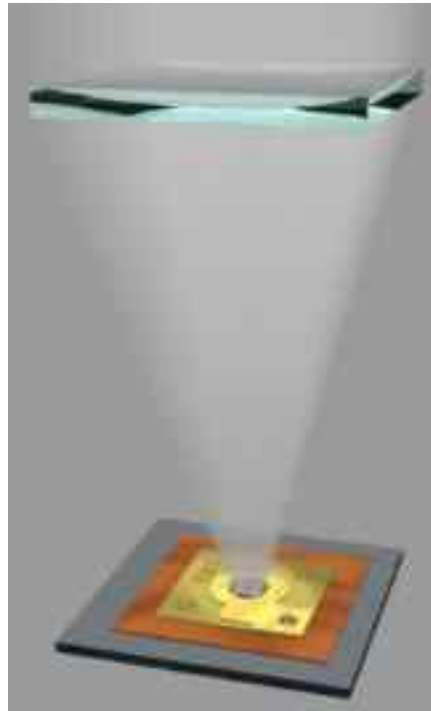
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# a-Si transparent thin film modules



Source: Schott Solar

# Photovoltaic energy conversion under optical concentration

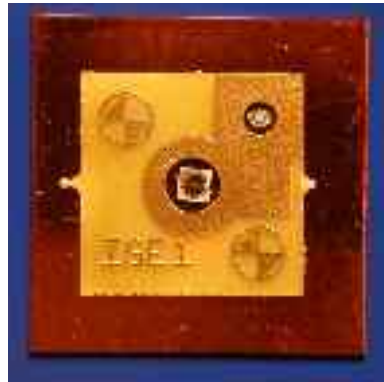


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# From wafer to PV power plant using high optical concentration



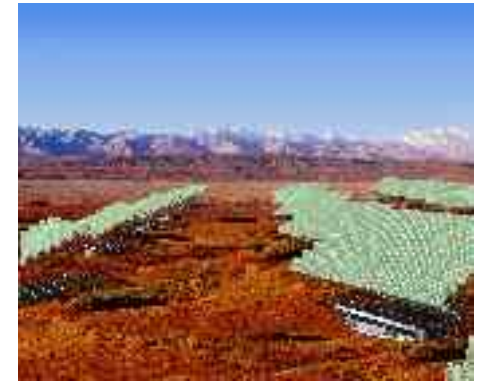
4-inch wafer with 1000 PV cells of highest efficiency



Cell and heat sink



Tracking unit



PV power plant

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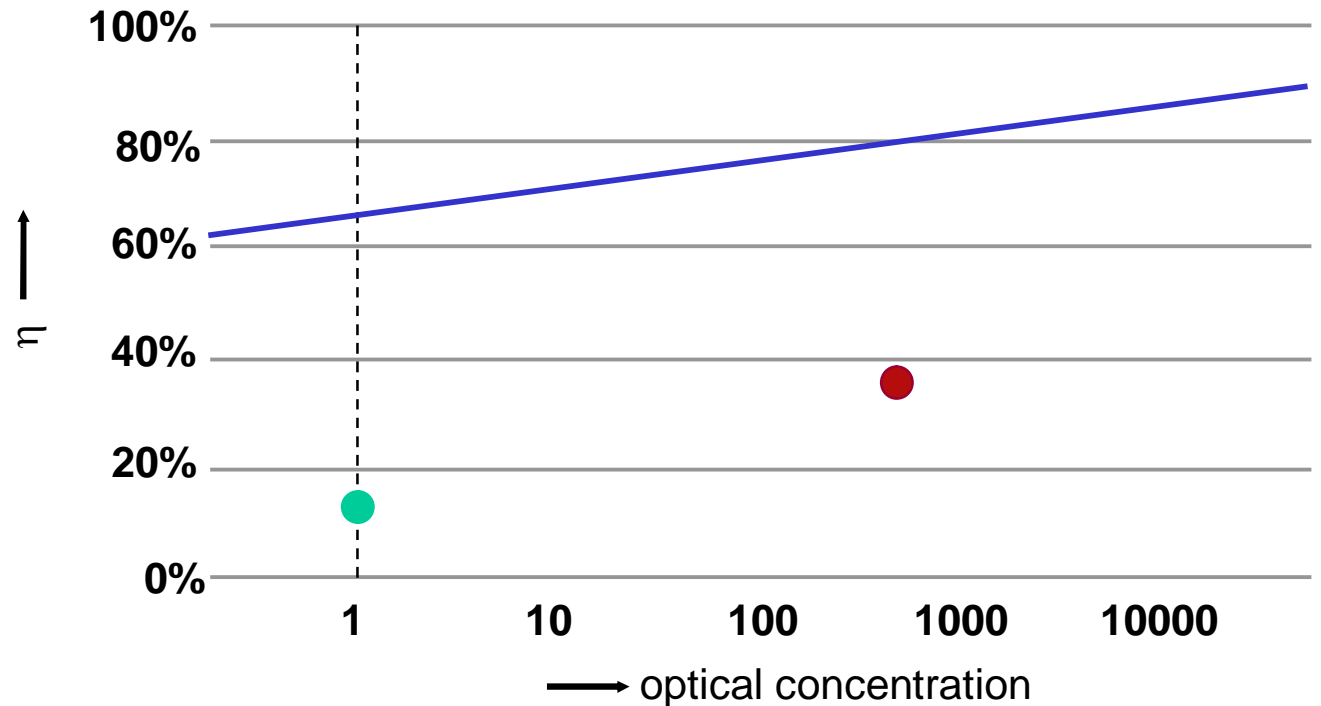
Prospects of further breakthroughs  
in photovoltaic energy conversion

Cross-disciplinary  
intensified basic scientific research  
is needed

# Thermodynamical limits of solar photovoltaic energy conversion

$T_s = 5\,777\text{ K}$

$T_c = 300\text{ K}$



Source: R. Sizmann 1991

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# A compilation of conceivable photovoltaic energy conversion paths



- Up and down conversion of photon energy
- Multi-bands cells
- Quantum well structure
- Electromagnetic antenna
- Auger excitation
- Extraction of hot carriers
- Thermophotonics

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# Bottlenecks on the way from scientific ideas to applications in the energy system, examples



- R&D budgets
- Missing reliable long term strategies
- Scientific and technology barriers
- Science-technology divide
- non optimal international co-operation

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# International Science Panel on Renewable Energies

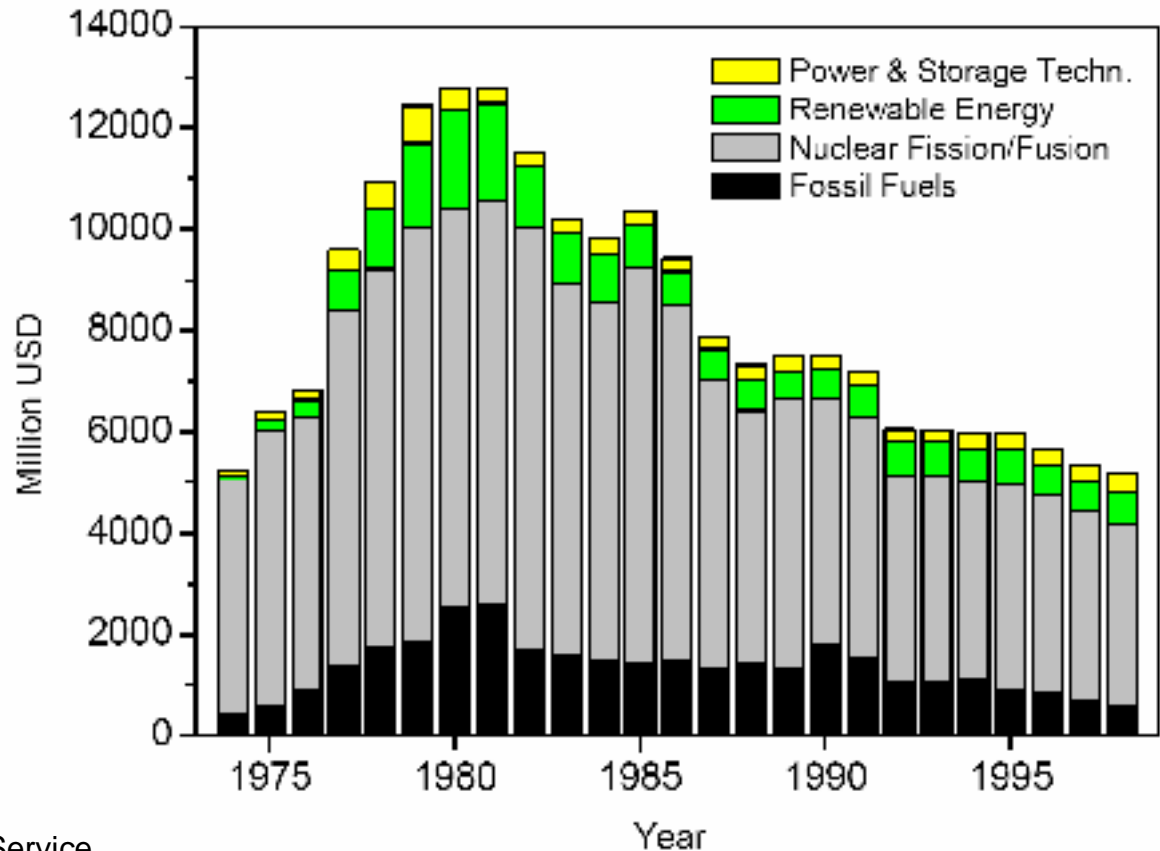
## ISPRE - a Scientific Panel in Formation

### The mission of ISPRES

- Providing strategic guidance for renewable energy S&T efforts worldwide
- Identifying gaps in existing efforts and recommending future S&T priorities and strategies
- Improving the effectiveness and coherence of national, regional and global S&T efforts

The International Council for Science (ICSU) is the institutional home for ISPRES and guarantor for highest scientific quality

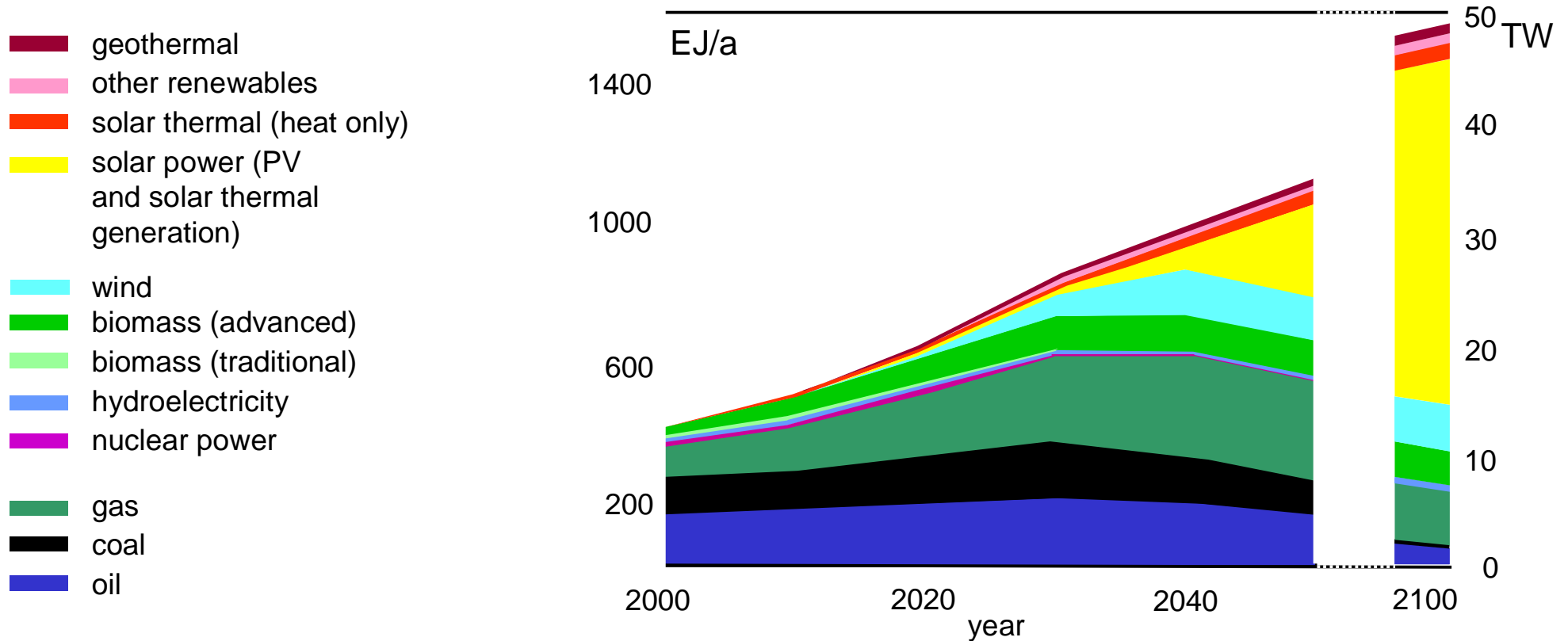
# Resource allocation to R&D on energy utilisation in OECD countries



Renewables 2004:  
1020 Million USD

Source: IEA Energy Technology R&D Statistics Service

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Source: German Advisory Council on Global Change, 2003, [www.wbgu.de](http://www.wbgu.de)

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Presentation:

[www.ise-solar.info](http://www.ise-solar.info)